C Programming Notes by CodeWithHarry

What is Programming?

Computer Programming is a medium for us to communicate with computers. Just like we use 'Hindi' or 'English' to communicate with each other, programming is a way for us to deliver our instructions to the computer.

What is C?

C is a programming language.
C is one of the oldest and finest programming languages.
C was developed by Dennis Ritchie at AT&T's Bell Labs, USA in 1972.

Uses of C

C Language is used to program a wide variety of systems. Some of the uses of C are as follows:

1> Major parts of Windows, Linux and other operating systems are written in C.

2> C is used to write driver programs for devices like Tablets, printers etc.

3> C language is used to program embedded systems where programs need to run faster in limited memory (Microwave, Cameras etc.)

4> C is used to develop games, an area where latency is very important. ie. Computer has to react quickly on user input.

Chapter 1: Variables, Constants & Keywords

Variables

A variable is a container which stores a 'value'. In Kitchen, we have containers storing Rice, Dal, Sugar etc. Similar to that Variables in C stores value of a constant. Example:

```
a = 3;      // a is assigned "3"
b = 4.7;    // b is assigned "4.7"
c = 'A';    // c is assigned 'A'
```

Rules for naming variables in C

1. First character must be an alphabet or underscore (_)
2. No commas, blanks allowed.
3. No special symbol other than (_) allowed.
4. Variable names are case sensitive.

We must create meaningful variable names in our programs. This enhances readability of our programs.

Constants

An entity whose value doesnt change is called as a constant.

A variable is an entity whose value can be changed.

Types of constants

Primarily, there are three types of constants :

1> Integer Constant → -1, 6, 7, 9
2> Real Constant → -322.1, 2.5, 7.0
3> Character Constant → 'a', '$', '@' (Must be enclosed within single inverted commas)

Keywords

These are reserved words, whose meaning is already known to the compiler. There are 32 keywords available in C.

auto
break
case
char
const
continue
default
do

double
long
return
register
short
signed
sizeof
static

int
else
enum
extern
float
for
goto
if

struct
switch
typedef
union
unsigned
void
volatile
while

Our First C Program

```
#include<stdio.h>

int main() {
printf("Hello, Iam learning C with Harry");
return 0;
}
```

File : first.c

Basic Structure of a C Program

All C programs have to follow a basic structure.
A C program starts with a main function and executes instructions present inside it.
Each instruction is terminated with a semicolon (;)

There are some rules which are applicable to all the C programs :

1. Every program's execution starts from main() function.
2. All the statements are terminated with a semicolon.
3. Instructions are case-sensitive
4. Instructions are executed in the same order in which they are written.

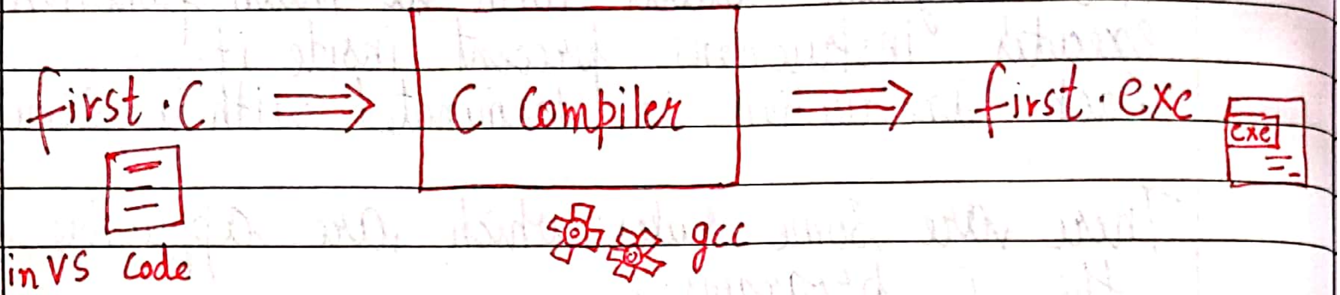
Comments

Comments are used to clarify something about the program in plain language. It is a way for us to add notes to our program. There are two types of comments in C.

1. Single line comment : // This is a comment
2. Multi-line comment : /* This is a
   multi line comment */

Comments in a c program are not executed and are ignored.

Compilation and Execution



A compiler is a computer program which converts a C program into machine language so that it can be easily understood by the computer.

A C program is written in plain text. This plain text is combination of Instructions in a particular sequence. The compiler performs some basic checks and finally converts the program into an executable.

Library functions

C language has a lot of valuable library functions which is used to carry out certain tasks. for instance printf function is used to print values on the screen

```
printf("This is %d", i);
```

%d for integers
%f for real values
%c for characters

Types of Variables

Wrong as 7·7 is real

1. Integer variables → int a = 3;
2. Real variables → ~~int a = 7·7;~~ float a = 7·7;
3. Character Variables → char a = 'B';

Receiving input from the User

In order to take input from the user and assign it to a variable, we use Scanf function

Syntax for using scanf :

```
Scanf ("%d", &i);
```

↳ This & is important !

& is the "address of" operator and it means that the supplied value should be copied to the address which is indicated by variable i.

Chapter 1 - Practice Set

Q1 Write a C program to calculate area of a rectangle:

(a) Using hard coded inputs
(b) Using inputs supplied by the User

Q2 Calculate the area of a circle and modify the Same program to calculate the volume of a cylinder given its radius and height.

Q3 Write a program to convert Celcius (Centigrade degrees temperature to Farenheit)

Q4 Write a program to calculate simple interest for a set of values representing principal, no of years and rate of interest!

Chapter 2 : Instructions and Operators

A C program is a set of Instructions. Just like a recepie - which contains Instructions to prepare a particular Dish.

Types of Instructions

1> Type declaration Instruction
2> Arithmetic Instruction
3> Control Instruction

Type declaration Instruction

```
int a;
float b;
```

Other Variations :

```
int i=10; int j=i; int a=2
int j= a + j - i;
```

```
float b = a+3; float a=1.1
```

=> ERROR! as we are trying to use a before defining it.

```
int a, b, c, d;
a = b = c = d = 30;
```

⇒ Value of a, b, c & d will be 30 each.

Arithmetic Instructions

operators

int i = (3 * 2) + 1

operands

Operands can be int / float etc.
+ - * / are arithmetic operators

```
int b=2, c=3;
intz; Z= b*c;  ✓ legal
int Z;   b*c =Z; × Illegal (Not allowed)
```

% → Modular division operator
% → Returns the remainder
% → Cannot be applied on float
% → Sign is same as of numerator (-5%2=-1)

5%2 =1   -5%2 = -1

Note :-

1) No operator is assumed to be present

```
int i= ab  → Invalid
int i= a*b → Valid
```

2) There is no operator to perform exponentiation in C
However we can use pow(x,y) from <math.h> (More later)

Type Conversion

An Arithmetic operation between

Int and Int → Int
Int and float → Float
Float and float → Float

$5/2 \rightarrow 2$ $\quad$ $5.0/2 \rightarrow 2.5$
$2/5 \rightarrow 0$ $\quad$ $2.0/5 \rightarrow 0.4$
} Important!!

Note :

`int a = 3.5;` In this case 3.5 (float) will be demoted to 3 (int) because a is not able to store floats.

`float a = 8;` a will store 8.0
8 → 8.0 (promotion to float)

Quick Quiz :

Q int k = 3.0/9 Value of k? and why?

S 3.0/9 = 0.333.. but since k is an int, it cannot store floats & value 0.33 is demoted to 0.

Operator precedence In C

$3 * x - 8y$ is $(3x) - (8y)$ or $3(x - 8y)$?

In C language simple mathematical rules like BODMAS, no longer applies.

The answer to the above question is provided by operator precedence & associativity.

Operator precedence ÷ The following table lists the operator priority in C

Priority	Operators
1st	* / %
2nd	+ −
3rd	=

Operators of higher priority are evaluated first in the absence of parenthesis.

Operator Associativity ÷ When operators of equal priority are present in an expression, the tie is taken care of by associativity.

$$x * y / z \Rightarrow (x * y) / z$$

$$x / y * z \Rightarrow (x / y) * z$$

*, / follows Left to right associativity

Control Instructions

Determines the flow of Control in a program

Four types of Control Instructions in C are :

1. Sequence Control Instruction
2. Decision Control Instruction
3. Loop Control Instruction
4. Case Control Instruction.

Chapter 2 - Practice Set

Q1 Which of the following is Invalid in C ?

(i) int a; b=a;

(ii) int v = 3^3;

(iii) char dt = '21 Dec 2020';

Q2 What data type will 3.0/8 - 2 return?

Q3 Write a program to check whether a number is divisible by 97 or not.

Q4 Explain step by step evaluation of 3*x/y-z+k where x = 2 y = 3 z = 3 k = 1

Q5 3.0 + 1 will be :

(a) Integer

(b) Floating point number

(c) Character

Chapter 3 - Conditional Instructions

Sometimes we want to watch comedy videos on YouTube if the day is sunday.
Sometimes we order junk food if it is our friend's birthday in the hostel.
You might want to buy an Umbrella if its raining and you have the money.
You order the meal if dal or your favorite bhindi is listed on the menu.

All these are decisions which depends on a condition being met.
In C language too, we must be able to execute instructions on a condition(s) being met.

Decision Making Instructions in C

→ If-else Statement
→ Switch Statement

If-else Statement

The syntax of an If-else statement in C looks like:

```
if (condition to be checked) {
        Statements-if-condition-true;
    }
else {
        Statements-if-condition-false;
    }
```

Code example :

```
int a = 23;
if (a >18){
    printf(" You can drive \n");
  }
```

Note that else block is not necessary but optional.

Relational Operators in C

Relational operators are used to evaluate Conditions (true or false) inside the if Statements. Some examples of relational operators are :

==, >=, >, <, <=, !=

== → equals
>= → greater than or equal to
!= → not equal to

Important note : '=' is used for assignment where as '==' is used for equality check.

The condition can be any valid expression. In C a non-zero value is considered to be true.

Logical Operators

&&, || and ! are three logical operators in C. These are read as "AND", "OR" and "NOT". They are used to provide logic to our C programs

Usage of Logical Operators:

(i) && → AND → is true when both the conditions are true

"1 and 0" is evaluated as false.
"0 and 0" is evaluated as false.
"1 and 1" is evaluated as true.

(ii) || → OR → is true when at least one of the conditions is true. (1 or 0 → 1) (1 or 1 → 1)

(iii) ! → returns true if given false and false if given true

!(3==3) → evaluates to false
!(3>30) → evaluates to true.

As the number of conditions increases, the level of indentation increases. This reduces readability. Logical operators come to rescue in such cases.

else if clause

Instead of using multiple if statements, we can also use else if along with if thus forming an if-else if-else ladder.

```
    if {
    // Statements;
      }
  else if {
        ...
        }
  else {...
    }
```

Using if - else if - else reduces indents
The last "else" is optional
Also there can be any number of "else if"

Last else is executed only if all conditions fail.

Operator precedence

Priority	Operator
1st	!
2nd	*, /, %
3rd	+, −
4th	< >, <=, >=
5th	==, !=
6th	&&
7th	||
8th	=

Conditional Operators

A short hand "if - else" can be written using the conditional or ternary operators

Condition ? expression-if-true : expression-if-false

Ternary operators

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Switch Case Control Instruction

Switch-Case is used when we have to make a choice between number of alternatives for a given variable.

```
Switch (integer-expression)
 {
   Case C1:
        Code;

   Case C2:
        code;

   Case C3 :
        code;

   default :
        Code;
 }
```

C_1, C_2 & C_3 → Constants

Code → Any valid C code.

The value of integer-expression is matched against C_1, C_2, C_3.... If it matches any of these cases, that case along with all subsequent "case" and "default" statements are executed.

* Quick Quiz: Write a program to find grade of a student given his marks based on below:

→ 90 - 100 → A
→ 80 - 90 → B
→ 70 - 80 → C
→ 60 - 70 → D
→ < 70 → F.

Important Notes

1> We can use switch-case statements even by writing cases in any order of our choice (not necessarily ascending)

2> char values are allowed as they can be easily evaluated to an integer

3> A switch can occur within another but in practice this is rarely done.

Chapter 3 - Practice Set

1 What will be the output of this program

```
int a = 10;
if (a = 11)
    printf ("I am 11");
else
    printf (" I am not 11");
```

2 Write a program to find out whether a student is pass or fail; if it requires total 40% and at least 33% in each subject to pass. Assume 3 subjects and take marks as an input from the user.

3 Calculate income tax paid by an employee to the government as per the slabs mentioned below:

Income Slab	Tax
2.5L - 5.0L	5%
5.0L - 10.0L	20%
Above 10.0L	30%

Note that there is no tax below 2.5L. Take income amount as an input from the user.

4 Write a program to find whether a year entered by the user is a leap year or not. Take year as an input from the user.

5 Write a program to determine whether a character entered by the user is lowercase or not.

6 Write a program to find greatest of four numbers entered by the user.

Chapter 4 - Loop Control Instruction

Why Loops

Sometimes we want our programs to execute few set of instructions over and over again. for ex: printing 1 to 100, first 100 even numbers etc.

Hence Loops make it easy for a programmer to tell computer that a given set of instructions must be executed repeatedly.

Types of Loops

Primarily, there are three types of loops in C language:

1. While loop
2. do - while loop
3. for loop

We will look into these one by one

While loop

```
While (condition is true) {

    // Code
    // Code

    }
```

⇒ The block keeps executing as long as the condition is true.

An example:

```
int i = 0

while (i < 10) {
    printf (" The value of i is %d", i); i++;
}
```

Note: If the condition never becomes false, the while loop keeps getting executed. Such a loop is known as an infinite loop.

Quick Quiz: Write a program to print natural numbers from 10 to 20 when initial loop counter i is initialized to 0.

The loop counter need not be int, it can be float as well.

Increment and decrement operators

i ++ → i is increased by 1
i -- → i is decreased by 1

```
printf(" --i = %d", --i);
```

This first decrements i and then prints it

```
printf (" i-- = %d", i--);
```

This first prints i and then decrements it

- * +++ operator does not exist ⇒ Important
- * += is compound assignment operator just like -=, *=, /= & %= ⇒ Also Important

do-While Loop.

The syntax of do-While loop looks like this:

```
do {
    // Code ;
    // Code ;
} while ( Condition)
```

do-while loop works very similar to while loop.

while → checks the condition & then executes the code

do-while → Executes the code & then checks the condition

do-while loop = While loop which executes at least once.

→ Quick Quiz: Write a program to print first n natural numbers using do-while loop.

Input : 4

Output :
```
1
2
3
4
```

for Loop

The syntax of for loop looks like this :

```
for( initialize ; test ; increment)
                         or decrement
{
  //Code;
  // Code;
  // Code;
}
```

Initialize → Setting a loop Counter to an initial value
Test → Checking a condition
Increment → Updating the loop Counter

An example :

```
for( i=0 ; i<3 ;i++) {
    printf( "%d", i);
    printf( "\n");
  }
```

Output :

```
0
1
2
```

Quick Quiz : Write a program to print first n natural numbers using for loop

A Case of Decrementing for loop

```
for (i=5; i; i--)
    printf("%d\n", i);
```

This for loop will keep on running until i becomes 0.

The loop runs in following steps:

1> i is initialized to 5
2> The condition "i" (0 or nono) is tested
3> The code is executed
4> i is decremented
5> Condition i is checked & code is executed if its not 0.
6> & so on until i is non 0

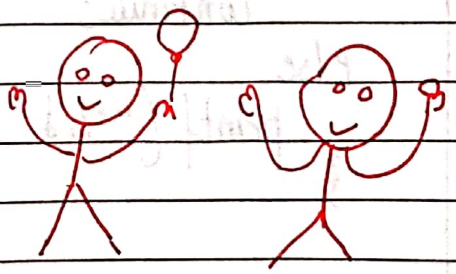
Quick Quiz: Write a program to print n natural numbers in reverse order.

The break Statement in C

The break statement is used to exit the loop irrespective of whether the condition is true or false.

Whenever a "break" is encountered inside the loop, the control is sent outside the loop

Let us see this with the help of an Example



```
for (i=0; i<1000; i++) {
  printf ("%d\n", i);
  if (i == 5) {
      break;
    }
  }
```

output ⇒

```
0
1
2
3
4
5
```

and not 0 to 100 ☺

The continue statement in C

The continue statement is used to immideately move to the next iteration of the loop.

The control is taken to the next iteration thus skipping everything below "continue" inside the loop for that iteration

Let us look at an example

```
 int skip = 5;
 int i = 0;

 while (i < 10) {
  if (i != skip)
       continue;
  else
       printf ("%d", i);
  }
```

Output ⇒ 5

and not 0 9

Notes :

1. Sometimes, the name of the variable might not indicate the behaviour of the program.
2. break statement completely exits the loop.
3. Continue statement skips the particular iteration of the loop.

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Chapter 4 - Practice Set

1. Write a program to print multiplication table of a given number n.

2. Write a program to print multiplication table of 10 in reversed order

3. A do while loop is executed :
   1. at least once
   2. at least twice
   3. at most once

4. What can be done using one type of loop can also be done using the other two types of loops - True or False ?

5. Write a program to sum first ten natural numbers using while loop.

6. Write a program to implement program 5 using for and do - while loop.

7. Write a program to calculate the sum of the numbers occuring in the multiplication table of 8. (Consider 8×1 to 8×10).

8. Write a program to calculate the factorial of a given number using a for loop.

9 Repeat 8 using while loops

10 Write a program to check whether a given number is prime or not using loops.

11 Implement 10 using other types of loops.

Project 1 : Number guessing Game

Problem: This is going to be fun!
We will write a program that generates a random number and asks the player to guess it. If the player's guess is higher than the actual number, the program displays "Lower number please". Similarly if the user's guess is too low, the program prints "Higher number please".
When the user guesses the correct number, the program displays the number of guesses the player used to arrive at the number.

Hint : Use loops
Use a random number generator

Chapter 5 - Functions and Recursion

Sometimes our program gets bigger in size and its not possible for a programmer to track which piece of code is doing what.
function is a way to break our code into chunks so that it is possible for a programmer to reuse them.

What is a Function ?

A function is a block of code which performs a particular task.
A function can be reused by the programmer in a given program any number of times.

Example and Syntax of a Function

```
# include <stdio.h>

Void display();          => Function prototype

int main() {
  int a;
  display();             => Function call
  return0;
  }

Void display() {         => function definition
  printf("Hi Iam display");
}
```

Function prototype
Function prototype is a way to tell the compiler about the function we are going to define in the program.
Here void indicates that the function returns nothing.

Function call
Function call is a way to tell the compiler to execute the function body at the time the call is made.
Note that the program execution starts from the main function in the sequence the instructions are written

Function definition
This part contains the exact set of instructions which are executed during the function call.
When a function is called from main(), the main function falls asleep and gets temporarily suspended. During this time the control goes to the function being called. When the function body is done executing main() resumes.

Quick Quiz → Write a program with three functions
1> Good morning function which prints "Good Morning"
2> Good afternoon function which prints "Good Afternoon"
3> Good night function which prints "Good night"

main() Should call all of these in order 1 → 2 → 3

Important Points

→ Execution of a C program starts from main()

→ A C program can have more than one function

→ Every function gets called directly or indirectly from main()

→ There are two types of functions in C. Lets talk about them

Types of Functions

1> Library functions → Commonly required functions grouped together in a library file on disk

2> User defined functions → These are the functions declared and defined by the user.

Why use functions?

1> To avoid rewriting the same logic again and again.

2> To keep track of what we are doing in a program

3> To test and check logic independently.

Passing values to functions

We can pass values to a function and can get a value in return from a function.

```
int sum(int a, int b)
```

The above prototype means that sum is a function which takes values a (of type int) and b (of type int) and returns a value of type int

function definition of sum can be:

```
int sum(int a, int b) {
    int c;
    c = a+b;
    return c;
    }
```

⇒ a and b are parameters

Now we can call Sum(2, 3); from main to get 5 in return.

↳ Here 2 & 3 are arguments

`int d = Sum(2, 3);` ⇒ d becomes 5

Note:

1> Parameters are the values or variable placeholders in the function definition. Ex a & b.

2> Arguments are the actual values passed to the function to make a call. Ex 2 & 3.

3) A function can return only one value at a time

4) If the passed variable is changed inside the function, the function call doesnt change the value in the calling function.

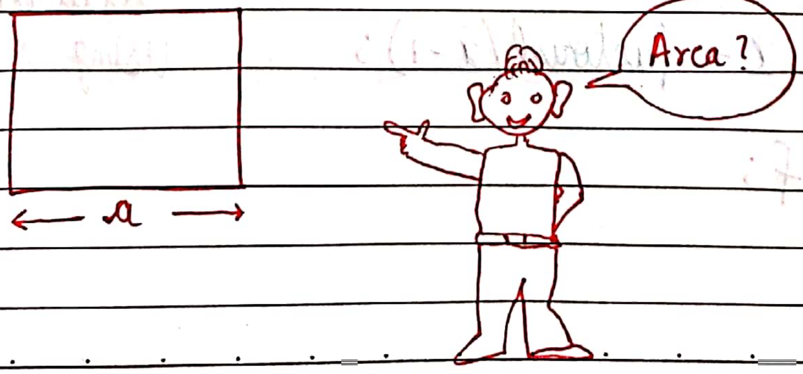
```
int change (int a) {
        a = 77;          => Misnomer
        return 0;
    }
```

change is a function which changes a to 77. No if we call it from main like this

```
  int  b = 22
   change (b);          => The value of b remains 22
  printf(" b is %d", b);
                        => prints "b is 22"
```

This happens because a copy of b is passed to the change function

Quick Quiz → Use the library functions to calculate the area of a square with side a.



Recursion

A function defined in C can call itself. This is called recursion. A function calling itself is also called 'recursive' function.

Example of Recursion

A very good example of recursion is factorial

$$factorial(n) = 1 \times 2 \times 3 \;\cdots\; \times n$$

$$factorial(n) = \underbrace{1 \times 2 \times 3 \cdots n-1}\; \times n$$

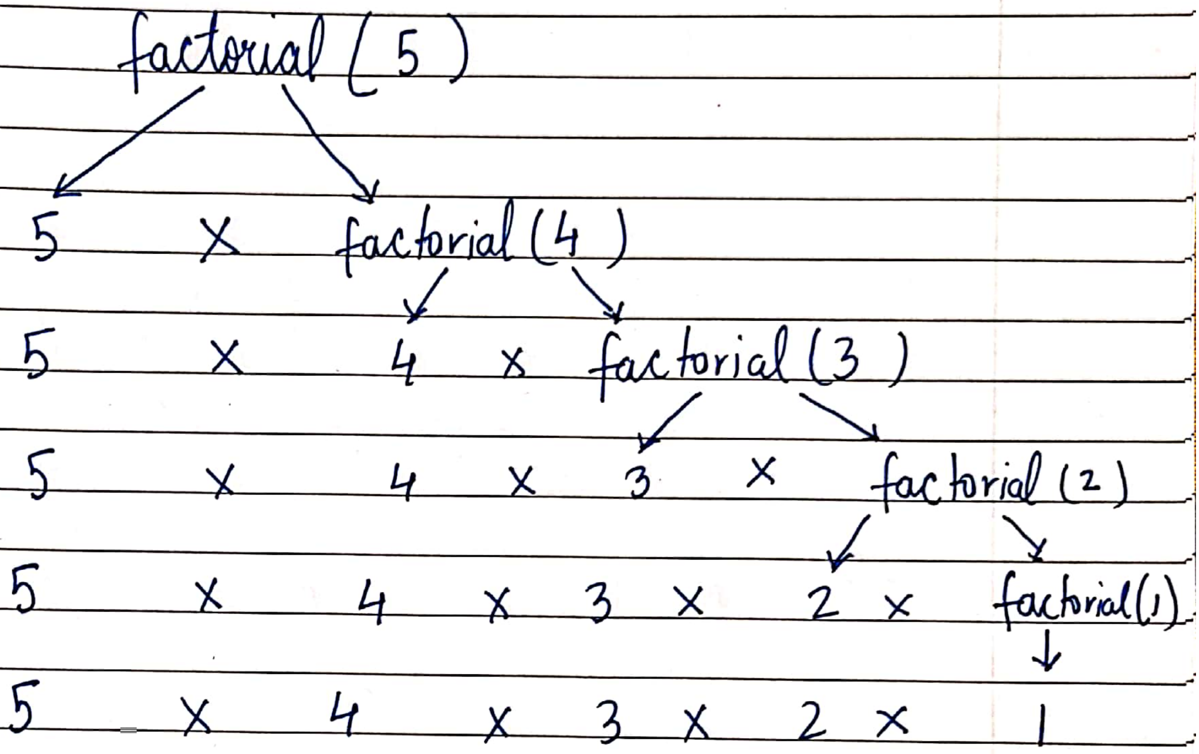
$$factorial(n) = factorial(n-1) \times n$$

Since we can write factorial of a number in terms of itself, we can program it using recursion.

```
int factorial (int x) {
    int f;
    if (x==0 || x==1)
            return 1;
    else
        f = x * factorial(x-1);

    return f;

  }
```

⇒ A program to calculate factorial using recursion

How does it work?


factorial (5)
5 x factorial (4)
5 x 4 x factorial (3)
5 x 4 x 3 x factorial (2)
5 x 4 x 3 x 2 x factorial (1)
5 x 4 x 3 x 2 x 1

Important Notes:

1. Recursion is sometimes the most direct way to code an algorithm
2. The condition which doesnt call the function any further in a recursive function is called as the base condition.
3. Sometimes, due to a mistake made by the programmer, a recursive function can keep running without returning resulting in a memory error.

Chapter 5 - Practice Set

1. Write a program using functions to find average of three numbers.

2. Write a function to convert Celcius temperature into farenheit.

3. Write a function to calculate force of attraction on a body of mass m exerted by earth ($g = 9.8 m/s^2$)

4. Write a program using recursion to calculate n^{th} element of fibonachi series.

5. What will the following line produce in a C program:

```
printf("%d %d %d \n", a, ++a, a++);
```

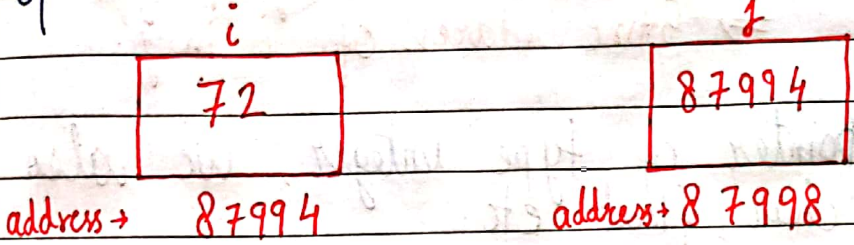
6. Write a recursive function to calculate the sum of first n natural numbers.

7. Write a program using functions to print the following pattern (first n lines)

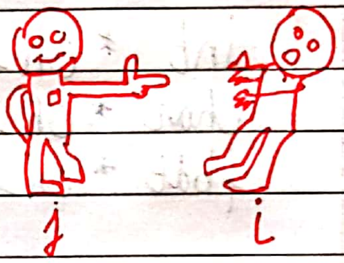
```
*
* * *
* * * * *
```

Chapter 6 - Pointers

A pointer is a variable which stores the address of another variable



j is a pointer
j points to i



The "address of" (&) operator

The address of operator is used to obtain the address of a given variable

If you refer to the diagrams above

&i => 87994
&j => 87998

Format specifier for printing pointer address is '%u'

The 'value at address' operator (*)

The value at address or * operator is used to obtain the value present at a given memory address. It is denoted by *

$*(\&i) = 72$
$*(\&j) = 87994$

How to declare a Pointer ?

A pointer is declared using the following Syntax

```
int *j;    => declare a variable j of type int-pointer
j = &i     => Store address of i in j
```

Just like pointer of type integer, we also have pointers to char, float etc.

```
int *ch_ptr;   → Pointer to integer
char *ch_ptr;  → Pointer to character
float *ch_ptr; → Pointer to float
```

Although its a good practice to use meaningful variable names, we should be very careful while reading & working on porgrams from fellow programmers.

A Program to demonstrate pointers

```
#include <stdio.h>
int main() {
   int i=8;
   int *j;
   j = &i;
  printf(" Add i = %u\n", &i);
  printf (" Add i = %u \n", j);
  printf (" Add j = %u \n", &j);
 printf (" Value i = %d \n", i);
 printf (" Value i = %d \n", *(&i));
printf (" Value i = %d \n", * j);
return 0;
}
```

Output:

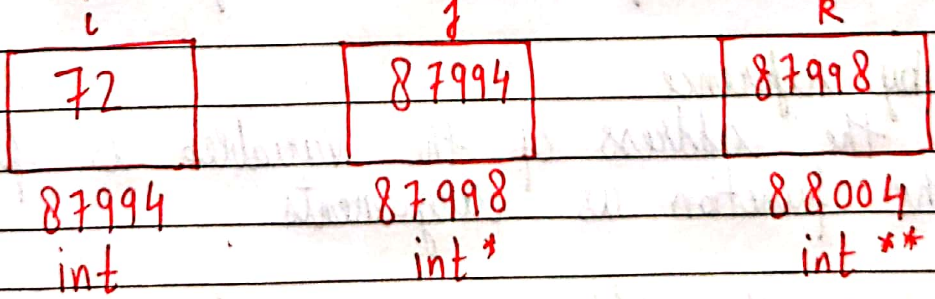
```
Add i = 87994
Add i = 87994
Add j = 87998
Value i = 8
Value i = 8
Value i = 8
```

This program sums it all. If you understand it, you have got the idea of pointers.

Pointer to a pointer

Just like j is pointing to i or storing the address of i, we can have another variable k which can further store the address of j. What will be the type of k

```
int **k;
k = &j;
```



We can even go further one level and create a variable l of type int*** to store the address of k. We mostly use int* and int** sometimes in real world programs.

Types of function calls
Based on the way we pass arguments to the function, function calls are of two types:

1> Call by value → Sending the values of arguments
2> Call by reference → Sending the address of arguments

Call by value
Here the value of the arguments are passed to the function. Consider this example:

int c = sum($\underset{x}{3}$, $\underset{y}{4}$); ⇒ assume x = 3 and y = 4

if sum is defined as sum(int a, int b), the values 3 and 4 are copied to a and b. Now even if we change a and b, nothing happens to the variables x and y.
This is call by value.

In C we usually make a call by value.

Call by reference
Here the address of the variables is passed to the function as arguments

Now since the addresses are passed to the function, the function can now modify the value of a variable in calling function using * and & operators. Example:

```
Void Swap (int *x, int *y)
{
   int temp;
   temp = *x;
    *x = *y;
    *y = temp;
}
```

This function is capable of swapping the values passed to it. if a = 3 and b = 4 before a call to swap(a, b), a = 4 and b=3 after calling swap.

```
int main() {
int a = 3
int b = 4      => a is 3 and b is 4
Swap(a,b)
return 0;      => Now a is 4 and b is 3
}
```

Chapter 6 - Practice Set

1. Write a program to print the address of a variable. Use this address to get the value of this variable.

2. Write a program having a variable i. Print the address of i. Pass this variable to a function and print its address. Are these addresses same? why?

3. Write a program to change the value of a variable to ten times of its current value. Write a function and pass the value by reference.

4. Write a program using a function which calculates the sum and average of two numbers. Use pointers and print the values of sum and average in main()

5. Write a program to print the value of a variable i by using "pointer to pointer" type of variable.

6. Try problem 3 using call by value and verify that it doesnt change the value of the said variable.

Chapter 7 - Arrays

An array is a collection of $\underbrace{\text{similar}}_{imp}$, elements.

One variable => Capable of storing multiple values

Syntax

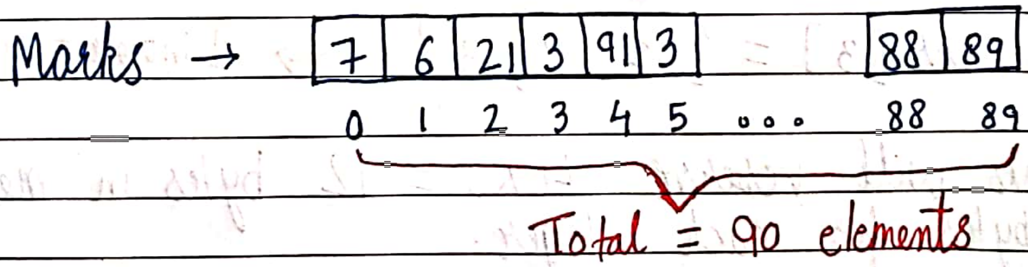
The syntax of declaring an Array looks like this:

int marks[90]; => Integer array
char name[20]; => Character array or String
float percentile[90]; => float array

The values can now be assigned to marks array like this:

marks[0] = 33;
marks[1] = 12;

Note: It is very important to note that the array index starts with 0!



Marks → | 7 | 6 | 21 | 3 | 91 | 3 | … | 88 | 89 |

0 1 2 3 4 5 … 88 89

Total = 90 elements

Accessing elements

Elements of an array can be accessed using:

`Scanf("%d", &marks[0]);` ⇒ Input first value

`printf("%d", marks[0]);` ⇒ output first value of the array

Quick Quiz → Write a program to accept marks of five students in an array and print them to the screen.

Initialization of an Array

There are many other ways in which an array can be initialized.

```
int cgpa[3] = {9, 8, 8}
float marks[] = {33, 40}
```

⇒ Arrays can be initialized while declaration

Arrays in memory

Consider this array:

`int arr[3] = {1, 2, 3}` ⇒ 1 integer = 4 bytes

This will reserve 4×3 = 12 bytes in memory
4 bytes for each integer.

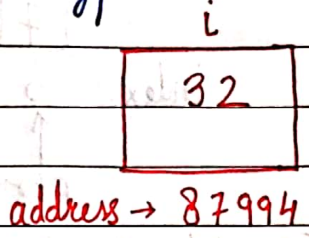
1	2	3
62302	62306	62310

⇒ arr in memory

Pointer Arithmetic

A pointer can be incremented to point to the next memory location of that type.

Consider this example

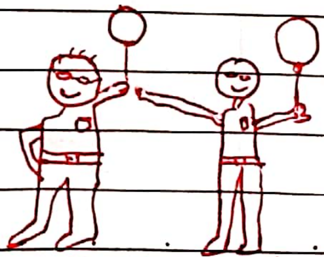


```
int i = 32;
int *a = &i;    => a = 87994
a++;            => Now a = 87998

char a = 'A';
char *b = &a;   => b = 87994
b++;            => Now b = 87995

float i = 1.7;
float *a = &i;  => Address of i or a = 87994
a++;            => Now a = 87998
```

Following operations can be performed on a pointers:

1. Addition of a number to a pointer
2. Subtraction of a number from a pointer
3. Subtraction of one pointer from another
4. Comparison of two pointer variables

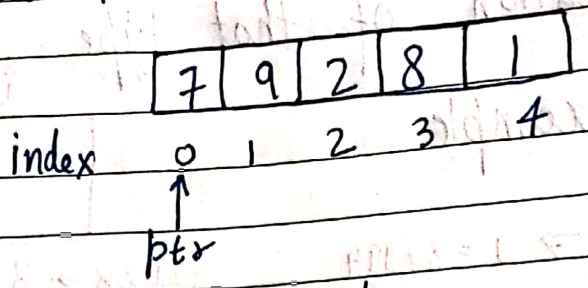
Quick Quiz → Try these operations on another variable by creating pointers in a separate program. Demonstrate all the four operations.



Yay! we understood pointer arithmetic

Accessing Arrays using pointers

Consider this array



If ptr points to index 0, ptr ++ will point to index 1 & so on...

This way we can have an integer pointer pointing to first element of the array like this:

```
int *ptr = &arr[0]; → or simply arr
ptr++;
  *ptr => will have 9 as its value
```

Passing arrays to functions

Arrays can be passed to the functions like this

```
printArray(arr,n);  => function call

Void printArray(int *i, int n); => function prototype
          or
Void printArray(int i[], int n);
```

Multidimensional Arrays

An array can be of 2 dimension / 3 dimension / n dimensions

A 2 dimensional array can be defined as:

```
int arr[3][2] = { {1, 4}
                  {7, 9}
                  {11, 22} };
```

We can access the elements of this array as arr [0][0], arr [0][1] & so on...

⇓ Value=1　　⇓ Value=4

2-D arrays in Memory

A 2d array like a 1-d array is stored in contiguous memory blocks like this:

arr[0][0] arr[0][1] ...

1	4	7	9	11	22

87224 87228 ..

Quick Quiz: Create a 2-d array by taking input from the user. Write a display function to print the content of this 2-d array on the screen.

Chapter 7 - Practice set

1 Create an array of 10 numbers. Verify using pointer arithmetic that (ptr+2) points to the third element where ptr is a pointer pointing to the first element of the array.

2 If S[3] is a 1-D array of integers then *(S+3) refers to the third element:
(i) True
(ii) False
(iii) Depends.

3 Write a program to create an array of 10 integers and store multiplication table of 5 in it.

4 Repeat Problem 3 for a general input provided by the user using scanf.

5 Write a program containing a function which reverses the array passed to it.

6 Write a program containing function which counts the number of positive integers in an array.

7 Create an array of size 3 x 10 containing multiplication tables of the numbers 2, 7 and 9 respectively.

8 Repeat problem 7 for a custom input given
= by the user.

9 Create a three-dimensional array and print
= the address of its elements in increasing order.

Chapter 8 - Strings

A string is a 1-D character array terminated by a null ('\0')
↳ This is null character

null character is used to denote string termination
characters are stored in contiguous memory locations

Initializing Strings

Since string is an array of characters, it can be initialized as follows:

```
char S[] = {'H', 'A', 'R', 'R', 'Y', '\0'};
```

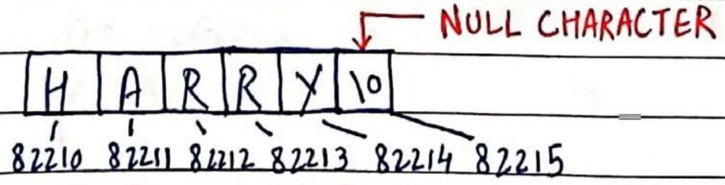
There is another shortcut for initializing strings in C language:

```
char S[] = "HARRY";
```

⇒ In this case C adds a null charater automatically.

Strings In Memory

A string is stored just like an array in the memory as shown below



Contiguous blocks in memory

Quick Quiz → Create a string using " " and print its content using a loop.

Printing Strings

A string can be printed character by character using printf and %c

But there is another convenient way to print strings in C.

```
Char St[ ] = " HARRY";
printf(" %S", St);   ⇒ prints the entire string.
```

Taking string input from the user

We can use %s with scanf to take string input from the user:

```
Char St[50];
Scanf("%S", &St);
```

Scanf automatically adds the null character when the the enter key is pressed.

Note:

1. The string should be short enough to fit into the array
2. Scanf cannot be used to input multi-word strings with spaces.

gets() and puts()
gets() is a function which can be used to receive a multi-word string.

```
Char st[30];
gets (st);  => The entered String is Stored in St!
```

Multiple gets() calls will be needed for multiple strings

Likewise, puts can be used to output a string.

```
puts(st);  => prints the string
              places the cursor on the next line
```

Declaring a string using pointers
We can declare strings using pointers

```
Char *ptr = "Harry";
```

This tells the compiler to store the string in memory and assigned address is stored in a char pointer

Note:
1> Once a string is defined using char st[] = "Harry", it Cannot be reinitialized to something else.
2> A string defined using pointers can be reinitialized
ptr = "Rohan";

Standard library functions for Strings

C provides a set of Standard library functions for string manipulation.

Some of the most commonly used string functions are:

Strlen()

This function is used to count the number of characters in the string excluding the null ('\0') character.

```
int length = Strlen(st);
```

These functions are declared under <String.h> header file

Strcpy()

This function is used to copy the content of second string into first string passed to it.

```
Char source[] = "Harry";
Char target[30];
Strcpy(target, Source); => target now
                           contains "Harry"
```

Target string should have enough capacity to store the Source String.

Strcat()

This function is used to concatenate two strings

```
Char S1[11] = "Hello";
Char S2[] = "Harry";
```

`Strcat(S1, S2);` ⇒ S_1 now contains "HelloHarry"
<No space in between>

Strcmp()

This function is used to compare two strings.
It returns: 0 if strings are equal
Negative value if first string's mismatching character's ASCII value is not greater than second string's corresponding mismatching character. It returns positive values otherwise.

```
Strcmp("Far", "Joke");
Strcmp("Joke", "Far");
```

⇒ Positive value
⇒ Negative value

Chapter 8 - Practice Set

1 Which of the following is used to appropriately read a multi-word String

(a) gets()
(b) puts()
(c) printf()
(d) scanf()

2 Write a program to take string as an input from the user using %c and %s. Confirm that the strings are equal.

3 Write your own version of strlen function from <string.h>

4 Write a function slice() to slice a string. It should change the original string such tat it is now the sliced string. Take m and n as the start and ending position for slice.

5 Write your own version of strcpy function from <string.h>

6 Write a program to encrypt a string by adding 1 to the ascii value of its characters.

7 Write a program to decrypt the string encrypted using encrypt function in problem 6.

8. Write a program to count the occurence of a given character in a string.

9. Write a program to check whether a given character is present in a string or not.

Chapter 9 - Structures

Arrays and strings ⟹ Similar data (int, float, char)

Structures can hold ⟹ dissimilar data

Syntax for creating Structures

A C Structure can be created as follows:

```
struct employee {
    int code;                ⟹ This declares a new
    float Salary;               user defined data-type!
    char name [10];
};
 → Semicolon is important
```

We can use this user defined data type as follows:

```
Struct employee e1;          ⟹ Creating a structure variable
Strcpy (e1.name, "Harry");
e1.code = 100;
e1.Salary = 71.22;
```

So a structure in C is a collection of variables of different types under a single name.

Quick Quiz: Write a program to store the details of 3 employees from user defined data. Use the structure declared above.

Why use structures ?

We can create the data types in the employee Structure separately but when the number of properties in a structure increases, it becomes difficult for us to create data variables without structures. In a nut shell :

(a) Structures keep the data organized.
(b) Structures make data mangement easy for the programmer.

Array of Structures

Just like an array of integers, an array of floats and an array of characters, we can create an array of structures.

```
Struct employee facebook[100];
```

⇒ An array of structures

We can access the data using:

```
facebook [0]. Code = 100;
facebook [1]. Code = 101;
                    ... & so on
```

Initializing Structures

Structures can also be initialized as follows:

```
Struct employee harry = { 100, 71.22, "Harry" };

Struct employee shubh = { 0 };
```

⇒ All elements set to 0

Structures in memory

Structures are stored in contiguous memory locations
For the structure e1 of type struct employee, memory layout looks like this:

	100	71.22	"Harry"
Address →	78810	78814	78818

In an array of structures, these employee instances are stored adjacent to each other.

Pointer to structures

A pointer to structure can be created as follows:

```
struct employee * ptr;
ptr= &e1;
```

Now we can print structure elements using:

```
printf ("%d", *(ptr).Code);
```

Arrow Operator

Instead of writing *(ptr).Code, we can use arrow operator to access structure properties as follows

```
*(ptr).Code  Or  ptr -> Code
```

Here -> is known as the arrow operator.

Passing Structure to a function

A structure can be passed to a function just like any other data type.

```
Void show (struct employee e);
```
⇒ Function prototype

Quick Quiz: Complete this show function to display the content of employee.

Typedef keyword

We can use the typedef keyword to create an alias name for data types in C. typedef is more commonly used with structures.

```
struct complex {
      float real;
      float img;
  };
```
⇒ struct complex C_1, C_2;
for defining complex numbers

```
typedef struct complex {
        float real;
        float img;
  } ComplexNo;
```
⇒ ComplexNo C_1, C_2;
for defining Complex numbers

Chapter 9 - Practice Set

1 Create a two dimensional Vector using structures in C

2 Write a function sumVector which returns the sum of two vectors passed to it. The vectors must be two-dimensional.

3 twenty integers are to be stored in memory. What will you prefer - Array or Structure ?

4 Write a program to illustrate the use of arrow operator -> in C.

5 Write a program with a structure representing a Complex number.

6 Create an array of 5 complex numbers created in Problem 5 and display them with the help of a display function. The values must be taken as an input from the user.

7 Write problem 5's structure using typedef Keyword.

8 Create a structure representing a bank account of a customer. What fields did you use and why ?

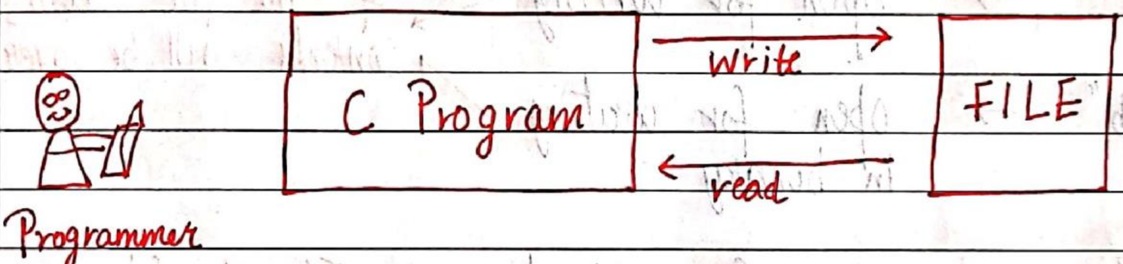
9 Write a structure capable of storing date.
= Write a function to compare those dates.

10 Solve problem 9 for time using typedef
= keyword.

Chapter 10 - File I/O

The Random Access Memory is volatile and its content is lost once the program terminates. In order to persist the data forever we use files.

A file is data stored in a storage device.
A C program can talk to the file by reading content from it and writing content to it.



FILE pointer

The "FILE" is a structure which needs to be created for opening the file.
A file pointer is a pointer to this structure of the file.

FILE pointer is needed for communication between the file and the program.

A FILE pointer can be created as follows:

```
FILE *ptr;
ptr = fopen("filename.ext", "mode");
```

EDGE

File opening modes in C

C offers the programmers to select a mode for opening a file.

Following modes are primarily used in C File I/O

"r" → open for reading

"rb" → open for reading in binary

→ If the file does not exist, fopen returns NULL

"w" → open for writing

"wb" → open for writing in binary

→ If the file exists, the contents will be overwritten

"a" → open for append → If the file does not exist, it will be created

Types of Files

There are two types of files:

1. Text files (.txt, .c)
2. Binary files (.jpg, .dat)

Reading a file

A file can be opened for reading as follows:

```
FILE *ptr;
ptr = fopen("Harry.txt", "r");
int num;
```

Let us assume that "Harry.txt" contains an integer
We can read that integer using:

```
fscanf(ptr, "%d", &num);
```

⇒ fscanf is file counterpart of scanf

This will read an integer from file in num variable.

Quick Quiz: Modify the program above to check whether the file exists or not before opening the file.

CLOSING the file
It is very important to close the file after read or write. This is acheived using fclose as follows:

```
fclose(ptr);
```

This will tell the compiler that we are done working with this file and the associated resources could be freed.

Writing to a file
We can write to a file in a very similar manner like we read the file

```
FILE *fptr;
fptr = fopen("Harry.txt", "w");
```

```
int num = 432;
fprintf(fptr, "%d", num);

fclose(fptr);
```

fgetc() and fputc()

fgetc and fputc are used to read and write a character from/to a file

`fgetc(ptr)` ⇒ used to read a character from file

`fputc('c', ptr);` ⇒ used to write character 'c' to the file

EOF : End of File

fgetc returns EOF when all the characters from a file have been read. So we can write a check like below to detect end of file

```
While (1) {
    ch = fgetc(ptr);
    if (ch == EOF) {
            break;
                }
    //code
    }
```

⇒ When all the content of a file has been read, break the loop!

Chapter 10 - Practice Set

1 Write a program to read three integers from a file.

2 Write a program to generate multiplication table of a given number in text format. Make sure that the file is readable and well formatted.

3 Write a program to read a text file character by character and write its content twice in a separate file.

4 Take name and salary of two employees as input from the user and write them to a text file in the following format:

name1, 3300
name2, 7700

5 Write a program to modify a file containing an integer to double its value.

2 → 4
prev. file new file

Project 2 : Snake, Water, Gun

Snake, water, gun or Rock, paper, scissors is a game most of us have played during School time. (I sometimes play it even now ☺)

Write a C program capable of playing this game with you.

Your program should be able to print the result after you choose Snake/water or gun.

Chapter 11 - Dynamic Memory Allocation

C is a language with some fixed rules of programming. For example: Changing the size of an array is not allowed.

Dynamic Memory Allocation

Dynamic memory allocation is a way to allocate memory to a data structure during the runtime. We can use DMA functions available in C to allocate and free memory during runtime.

Functions for DMA in C

Following functions are available in C to perform Dynamic memory Allocation:

1. malloc()
2. calloc()
3. free()
4. realloc()

malloc() function

malloc stands for memory allocation. It takes number of bytes to be allocated as an input and returns a pointer of type void

Syntax:

```
ptr = (int*) malloc(30* sizeof(int))
```

(int*) ↓ casting void pointer to int

30 ↓ space for 30 ints

sizeof(int) → returns size of 1 int

The expression returns a null pointer if the memory cannot be allocated.

Quick Quiz: Write a program to create a dynamic array of 5 floats using malloc().

Calloc() function

Calloc stands for continuous allocation.
It initializes each memory block with a default value of 0.

Syntax:

```
ptr = (float*) calloc(30, sizeof(float));
```

Allocates contiguous space in memory for 30 blocks (floats)

If the space is not sufficient, memory allocation fails and a NULL pointer is returned.

Quick Quiz: Write a program to create an array of size n using calloc where n is an integer entered by the user.

free() function

We can use free() function to de allocate the memory.
The memory allocated using calloc/malloc is not deallocated automatically.

Syntax :

```
free(ptr);
```

⟹ Memory of ptr is released.

Quick Quiz : Write a program to demonstrate the usage of free() with malloc().

realloc() function

Sometimes the dynamically allocated memory is insufficient or more than required.

realloc is used to allocate memory of new size using the previous pointer and size.

Syntax :

```
ptr = realloc(ptr, newSize);
ptr = realloc(ptr, 3* sizeof(int));
```

⇓

ptr now points to this new block of memory capable of storing 3 integers.

Chapter 11 - Practice Set

1 Write a program to dynamically create an array of size 6 capable of storing 6 integers.

2 Use the array in problem 1 to store 6 integers entered by the user

3 Solve problem 1 using calloc()

4 Create an array dynamically capable of storing 5 integers. Now use realloc so that it can now store 10 integers.

5 Create an array of multiplication table of 7 upto 10 (7×10 = 70). Use realloc to make it store 15 numbers (from 7×1 to 7×15).

6 Attempt problem 4 using calloc().